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Nutrition and Aeration in Relation to the Growth of Cannabis saliva

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Nutrition and Aeration in Relation to the Growth of *Cannabis sativa*

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INTRODUCTION

The common commercial variety of dioecious hemp, *Cannabis sativa* when grown under favorable conditions is known to exhibit not only sexual dimorphism but certain other fairly uniform structural characteristics. Plants of the two sexes are distinguished by difference in the rate of growth, habit, and time of flowering. Certain characteristic vegetative traits such as the transition from three to five to seven compound leaflets and a modification in habit from opposite to alternate phyllotaxy, not usually correlated with sex, normally also occur with great regularity at certain stages of growth.

An experiment was undertaken to determine possible variations produced in the normal expression of these vegetative traits and the usual sexual dimorphism by growth conditions varying from favorable to relatively adverse. Responses studied were the normal sequense of five to seven leaflets, opposite to alternate phyllotaxy, anthesis subsequent to the inflexion in rate of stem elongation, and whether this normal sequence could be altered; the differences in the growth responses induced by aeration of substrate under conditions of high and low nutrition; the effect of these two nutritional levels upon the most conspicuous changes (flowering, phyllotaxy, and five to seven leaflets) and the relation of the foregoing to periods of maximum growth.

The test procedures for these purposes listed involved the use of (1) favorable versus comparatively inadequate nutrition, (2) soil aeration versus absence thereof, and (3) use of long day which delays flowering. Since differences in substrate might be expected to cause variation in rate of growth, size, and floral numbers, special attention was focussed on variations which seem to be the more stable structural characteristics already enumerated including sex ratios, even though all major contrasts in growth were noted. It also seemed desirable to determine if well and poorly nourished plants differentiated the same number of nodes before flowering or whether variations in substrate induced any significant alterations in these responses (Dobrunov, 1934).

Methods

Seeds of Kentucky Hemp were planted on March 1, 1948 in flats of one half sand and one half loam. The flats were placed in the greenhouse at temperatures between 18°-21°C. When the seedlings were 6 cm. high (13 days) they were transplanted to 6 inch clay pots, eventually having 3 plants per pot.

There were 48 pots comprising the group. All were provided with a bottom drainage of one half inch layer of gravel and filled with a sandy loam mixture (1 part loam to 2 parts sand). All 48 pots contained a two inch square block of porus pumice, 24 pots were aerated by forcing air through the pumice block.

One half of each of these above two groups were given a supplementary source of nutrients in the amount of 0.10% total solutes (Series H); the others received 0.05% total solutes (Series L). Nutrient solution was Withrows Medium Light (Withrow and Biebel, 1938) with micro-nutrients added. Every three days each pot was given 300-400cc of nutrient solution. Distilled water was supplied as needed between feeding periods.

Experimental Series

Total solutes 0.10%, aerated, 12 pots, designated as Series *HA*
Total solutes 0.10%, nonaerated, 12 pots, designated Series *H*
Total solutes 0.05%, aerated, 12 pots designated as Series *LA*
Total solutes 0.05%, nonaerated, 12 pots, designated Series *L*

The plants were grown at greenhouse temperatures ranging from 24°-29°C during the day and at night temperatures of 18°-24°C. The relative humidity was maintained approximately at 50%. Daily illumination was 14 hours of light (supplemented by mazda bulbs during February, March, and April). A minimum intensity of 200 foot candles was allowed.

Growth records were kept at 3 day intervals with special emphasis on the differences of the two sexes. Data includes sex ratios in H and L nutrient series as well as in aerated and nonaerated series. The following measurements and observations were taken on staminate and pistillate plants; mean stem elongation, mean number of nodes, shift from three to five to seven compound leaflets, shift from alternate to opposite foliation. Flowering dates were noted and the mean height at anthesis (time at which the first pollen was shed from the anther of staminate plants and first observence of filiform styles of female plant) was also noted.

Plants were harvested at the time of anthesis in each of the series and separated according to sex. Fresh and dry weights of total tops and roots were made using the Brabender Moisture Tester. Samples

were dried to a constant weight at 110°C. Where possible three samples were taken from each top of eight plants of each of the four series. In the case of the roots two samples of each root were taken, the number of plants being the same as for the tops.

Data and Discussion

Plants of all four series developed rather uniformly for the first 40 days, after which definite differences in growth became apparent, (Fig. 1). There after, variation in rate of stem elongation, leaf size, texture, thickness and color were gradually developed between the series. After 50 days gross morphological differences between the two sexes in each series were observed, and at 60 days the staminate and pistillate plants could be definitely identified.

During the first 44 days the HA and L series were elongating at approximately the same rate and characterized by simultaneous shifting from opposite to alternate phyllotaxy at the same node. The H and LA series showed responses similar to those of the HA and L series except the rate of stem elongation was less (Fig. 1). The greatest difference in all the series became apparent between the 40th and 60th days and were maintained throughout the experiment. Stems of the HA series definitely attained the greatest

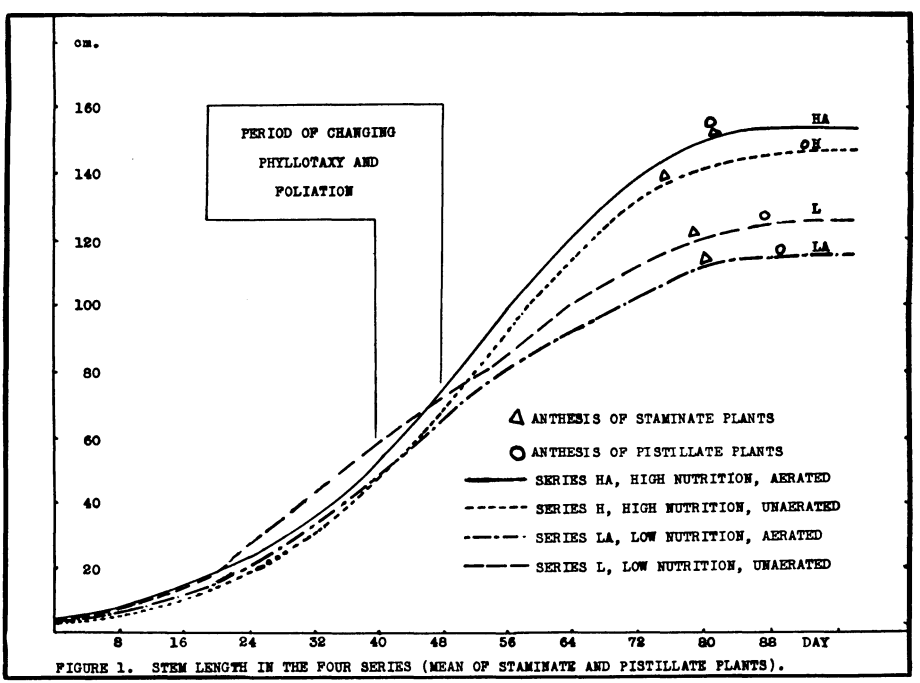

FIGURE 1. STEM LENGTH IN THE FOUR SERIES (MEAN OF STAMINATE AND PISTILLATE PLANTS).

rate of elongation, a longer average internodal length, and greater number of nodes (Table III).

Plants in all series changed from three to five leaflets between the fifth and sixth node at thirty-one days, irrespective of experimental treatment. The change from five to seven compound leaves occurred at the 50th day and generally at the 7th node. There was slight variation as to when shift from opposite to alternate foliation took place. In the H and LA series this shift was at the 10th node and in the HA and L series the shift was at the 11th node. The age at the time of this shift in leaf arrangement was approximately 65 days (Table IV).

Striking results were obtained as to the effects of aeration and nonaeration on sandy loam soil substrates low in nutrient. Aeration was found to be beneficial to the general growth of the plant under conditions of adequtae nutrition (Free and Livingston, 1917). Abundant aeration under relatively high nutrient conditions increased the over all height of the plant (Fig. 1). There were increases in amount of succulence, longer internodes, rates of elongation, and number of nodes along with greater dry weights with a shortening of the growth period. Increases in the morphological size under these same conditions have been noticed in corn, tomato, sunflower, and cotton, as well as hemp (Albert and Armstrong, 1931). As stated by Loehwing, 1934, the physiological effect of aeration on tops under high nutrient supplies appears to be an acceleration in development with earlier maturation rather than increased longevity. Other investigators have reported that the root aeration is important in relation to the reproductive phase of growth. Hemp grown under the conditions in our experiment matured, in one series, earlier, and in the other series both sexes matured at the

Table I.

Fresh Weight in Grams and Percent of Moisture of Total Tops and Roots Computed as Means for 8 Plants or Each Sex in Each Series

	Fresh Weight		Total Fr. Weight	Percent Moisture	
	tops	roots	tops & roots	tops	roots
H male	39.2	17.5	56.7	72.4	85.0
H female	50.0	13.0	63.0	65.5	87.0
HA male	30.0	22.2	52.2	68.5	84.0
HA female	58.0	32.0	90.0	67.2	85.6
L male	24.6	13.5	38.1	67.6	85.0
L female	37.0	24.0	61.0	66.0	85.0
LA male	25.0	11.4	36.4	64.0	80.4
LA female	34.0	7.0	41.0	66.0	80.8

Table II.

Dry Weight in Grams and Percent of Dry Weight of Total Tops and Roots Computed as Means for 8 Plants of Each Sex in Each Series

	Dry Weight top	Dry Weight root	Total Dry Weight tops & roots	Percent Dry Weight tops	Percent Dry Weight roots
H male	10.8	2.6	13.4	27.6	15.0
H female	17.2	1.7	18.9	34.5	13.0
HA male	9.4	3.6	13.0	31.5	16.0
HA female	19.0	4.6	23.6	32.8	14.0
L male	8.0	2.0	10.0	32.4	15.0
L female	13.1	3.6	16.7	34.0	15.0
LA male	9.0	2.2	11.2	36.0	20.6
LA female	11.6	1.1	12.7	34.0	20.2

Table III.

Major Contrasts Between Staminate and Pistillate Hemp Plants at Anthesis

SERIES	H		HA		L		LA	
SEX	M	F	M	F	M	F	M	F
Mean number of nodes at anthesis	18	23	20	17	17	17	17	17
Stem lengths in cm at anthesis	138	158	170	148	132	120	123	124
Age of plant at flowering, days	72	96	79	79	75	87	75	87
Sex ratio %	58	42	50	50	32	68	57	43

Table IV.

Age at Changes in Phyllotaxy and Number of Leaflets in Staminate and Pistillate Hemp Plants

SERIES	H		HA		L		LA	
SEX	M	F	M	F	M	F	M	F
Total number nodes at flowering	18	23	20	17	17	17	17	16
Node where shift from 3-5 leaflet	5	6	6	5	6	5	5	5
Age (in days)	31	31	31	31	31	31	31	31
Node where shift from 5-7 leaflet	7	7	7	7	7	7	7	7
Age (in days)	35	33	35	35	40	40	50	50
Node where shift from opposite to alternate	10	10	11	11	11	11	10	10
Age (in days)	35	40	50	45	60	60	65	65
Average internodal length, cm.	8	7	9	9	8	7	7	7

same time. Abundant oxygen in the soil favored the early setting of flowers of both male and female plants of Cannabis (Table III).

The roots grown under these same conditions favored increased branching and bulk as well as longer and more fibrous root systems. Greater acceleration in growth was noted also under conditions of high nutrition plus aeration. There was a greater total dry weight of roots and tops, which is the main criterion of growth (Tables I, II).

Under conditions of high nutrition without aeration there were substantial increases in gross stature, but these increases do not compare with those obtained under low nutrition with or without aeration. The root system was smaller, branching was noticed to a very small degree, and the length of roots was reduced. There was a definite reduction in the total dry weight of the tops as well as the roots under these conditions. In the case of high nutrition there was great difference in the total dry weight of the tops in respect to aeration but there was not, however, in the total dry weight of the roots (Table II).

The most striking results were obtained with the two series grown under low nutrition, one aerated and the other nonaerated. Comparing the aerated plants with the nonaerated ones there were the following differences: there was a difference in total height, the nonaerated series being greater (Fig. 1). The unaerated series was greater in total stem length, accelation of growth throughout the growing period, internodal lengths, total fresh and dry weights of tops and roots (Table I, II). Aeration under high nutrition favored the growth of both staminate and pistillate plants while aeration under conditions of low nutrition depressed growth. The effect of increased oxygen tension of the soil reversed solute absorption under conditions of low nutrient supplies as judged by the amount of dry weight and gross statute. The fact that the total dry weights of the aerated roots were lower than those of the nonaerated ones indicates that root absorption from small supplies of nutrients is dependent on the oxygen tension. According to Arrington and Shive, 1936, the oxygen and carbon dioxide tensions are the direct result of absorption, translocation, and metabolism of available nutrients (Shive and Pepkowitz, 1944).

The time of shift from opposite to alternate foliation followed the change from 5 to 7 leaflets by 16 days in both low series (Table IV). The H series showed both of the changes taking place at the same time in the two sexes (Table IV). Schaffner, 1928, has shown changes in phyllotaxy (opposite to alternate) by repeated rejuven-

ation in a changing photoperiod. The high nutrient group plus aeration showed the characteristic change from 5 to 7 leaflets after 36 days but shift in phyllotaxy was at different times for the two sexes (Table IV).

Summary and Conclusions

This experiment was performed to note the effect of aeration and nutrition upon the growth of *Cannabis sativa* and the resulting sex expression.

Four different conditions were set up as follows:

High nutrition, 0.10% total solutes, Series H.
High nutrition plus aeration of roots, Series HA.
Low nutrition, 0.05% total solutes, Series L.
Low nutrition plus aeration of roots, Series LA.

The following conclusions may be deduced from the experimental results presented.

a. Under conditions of high nutrition and low nutrition plants of the former series were definitely better developed as to height, texture of leaves, root development, number of nodes, size, and rate of growth.

b. Under conditions of high nutrition and high nutrition plus aeration, plants in the latter series were more out standing in all four series, darker leaves, greater mean rate of stem elongation, greater eventual stem length, simultaneous flowering of both staminate and pistillate plants and better root development including formation of secondary roots.

c. Under conditions of low nutrition with and without aeration plants of the latter series were the most poorly developed when compared with the other three series.

d. Root aeration under conditions of low nutrition appear to aggravate the effects of mineral deficiency, whereas aeration is beneficial to plants on a more favorable nutrient supply.

e. It appears that on the basis of dry weights aeration is instrumental in the accumulation of solutes in the stems, leaves, and petioles but not in the accumulation of dry material in the root under conditions of low nutrient.

f. The sex ratios were very nearly the same for all groups except in the L series where the ratios were one staminate to two pistillate plants; no definite conclusions can be drawn on the basis of the substrate.

g. The lapse of time between the normal sequence of 5 to 7 leaflets, opposite to alternate phyllotaxy, and anthesis subsequent to inflexion in rate of stem elongation can be altered.

h. Aeration enhances use of nutrients when in ample supply but it aggravates injury due to nutrient deficiency.

i. Low nutrition was marked by a lack of sharp inversion in growth rate resulting in a static condition.

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